Real-Time Speckle Imaging For Video Surveillance

C. Carrano, D. A. Silva

Atmospheric blurring, sensor platform motion, and optical aberrations reduce the resolution and contrast in surveillance images recorded over long (>0.5 km) atmospheric paths. The resolution loss can be an order of magnitude or more. By overcoming this loss and restoring resolutions to near the diffraction limit, it is possible to identify people from several kilometers, and vehicles from multiple tens of kilometers. This capability is potentially very important for the intelligence and DoD communities, as well as for law enforcement and security agencies.

Last year we successfully demonstrated a proof-of-principle high-resolution video-surveillance system that dramatically enhanced the resolution and contrast in surveillance images of people, vehicles, and other targets. The problem is that the existing system acquires and processes data far too slowly for most real-world applications. The target must remain still during the 2 to 3 min required for data acquisition, and then there is a wait, from 10 to 30 min or more, for a processed image.

The objective of this new project is to test a real-time implementation strategy for high-resolution speckle-imaging systems.

We began by evaluating technology options for both image acquisition and high-speed image processing. To eliminate the need for the target to be still for minutes, we purchased a video-rate CCD camera and a compatible frame-grabber. It is unnecessary to go much beyond video rates since speckle imaging requires some time (~10 to 20 ms) between frames for the atmosphere to decorrelate.

On the image processing side, although there are a number of avenues that could be pursued for speeding up the image processing, such as digital signal processing (DSP) boards or field programmable gate arrays (FPGAs), we decided to proceed with a multiprocessor, general purpose computer platform. This choice was made primarily to simplify the software implementation, which is quite complex, and to ensure compatibility between computing platforms.

Since taking delivery of the system components, much progress has been made on system integration, interfacing, and image processing software. The figure shows the system being tested outside. The camera and frame-grabber have been successfully integrated into the system and tested. The advertised frame-rate of 34 FPS proved to be true. The user interface allows for full control of the camera parameters (*e.g.,* exposure time, gain, offset, and region of interest selection), as well as a live image update for target viewing, alignment, and focusing. To obtain multiple images at full frame-rate requires only the push of a button, after which it is possible to view them, save them, or use them in subsequent image processing.

As projected in our deliverable schedule, our current image processing options include the ability to perform image stabilization. Stabilization, while useful on its own, is actually the first step performed in speckle image processing. Good progress has also been made on unifying and converting the speckle image processing software into C. The original versions were implemented with a combination of new IDL routines and legacy Fortran code, which, while fine for prototyping, is not optimal for speed. Through this effort, we have already experienced a tremendous increase in speed and simplification of the image processing steps. For example, to process 30, 1024 - x -1024 pixel-sized images on a single 1.9-GHz processor now takes between 30 and 60 s, depending on the desired output resolution.

Next year we plan to parallelize the speckle processing software over the four processors, with expected processing times under 20 s for many cases, and perform field testing of the system with static targets. We will also begin to look at slowly moving targets.

Photograph of the real-time video-surveillance system being tested outdoors.